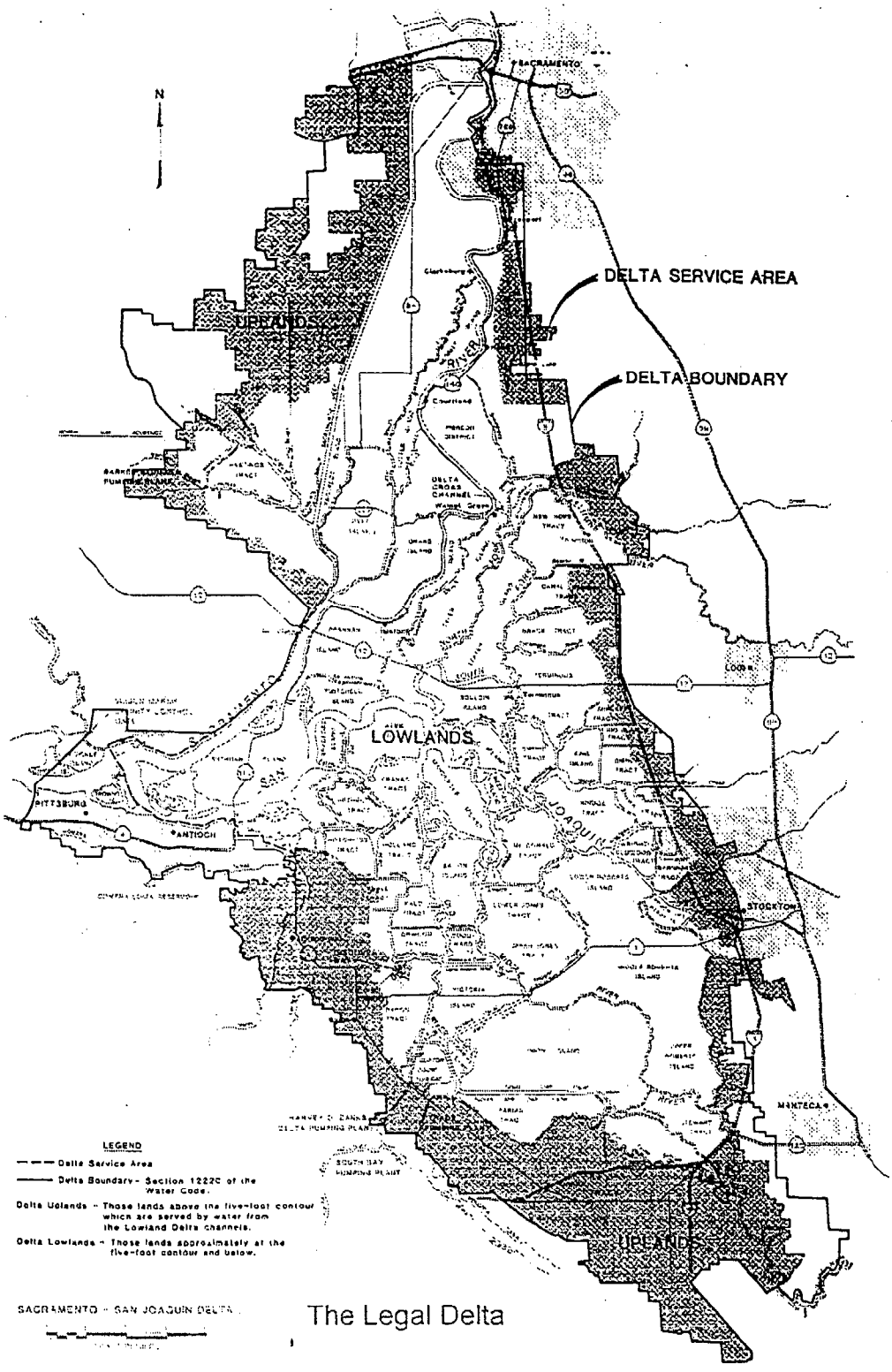
FIGURE 2

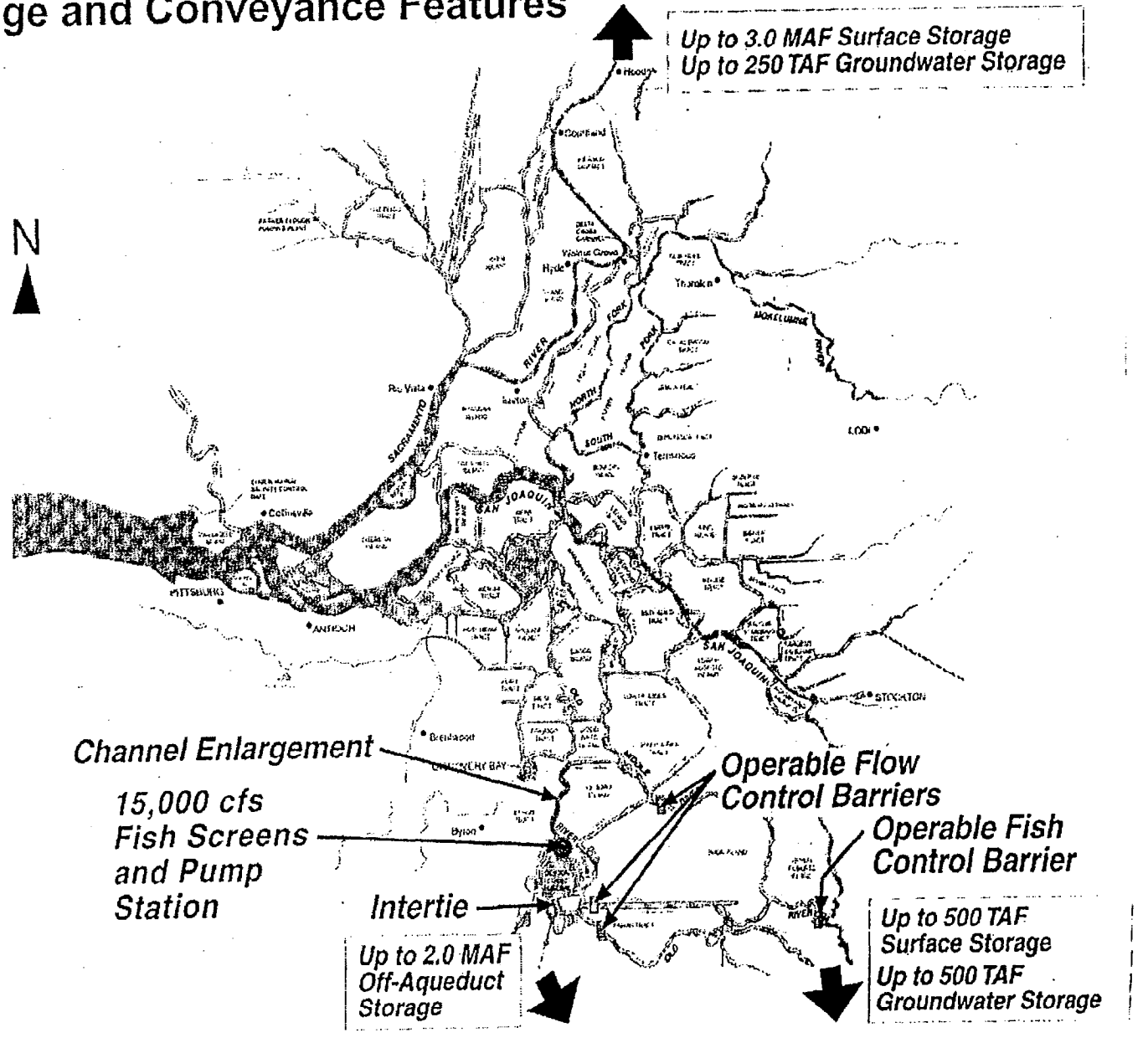
The Legal Sacramento/ San Joaquin Delta



The Legal Delta

Alternative 1

Storage and Conveyance Features

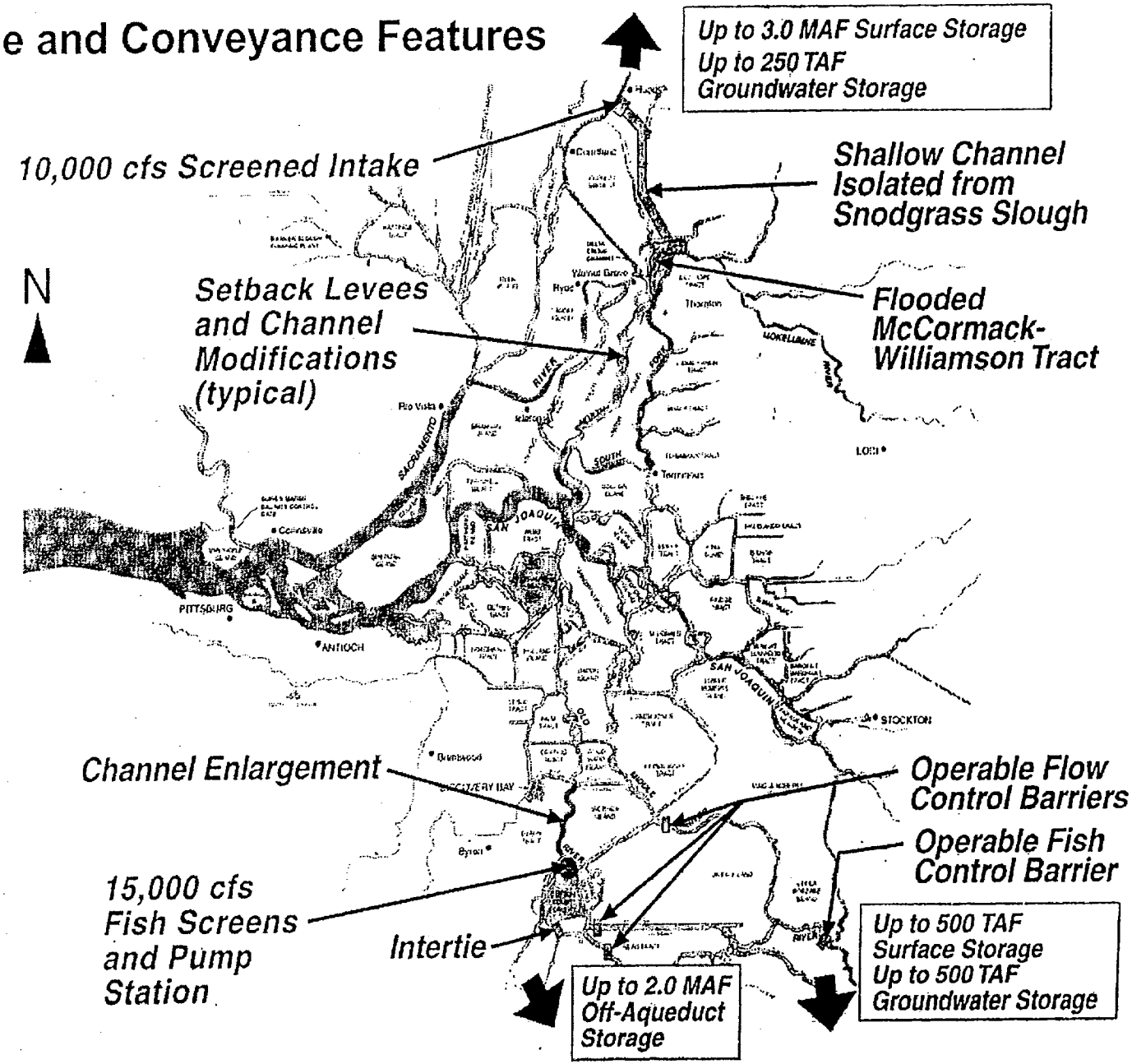


Alternative 1

FIGURE 3

Alternative 2

Storage and Conveyance Features



Alternative 2

FIGURE 4

Alternative 3

Storage and Conveyance Features

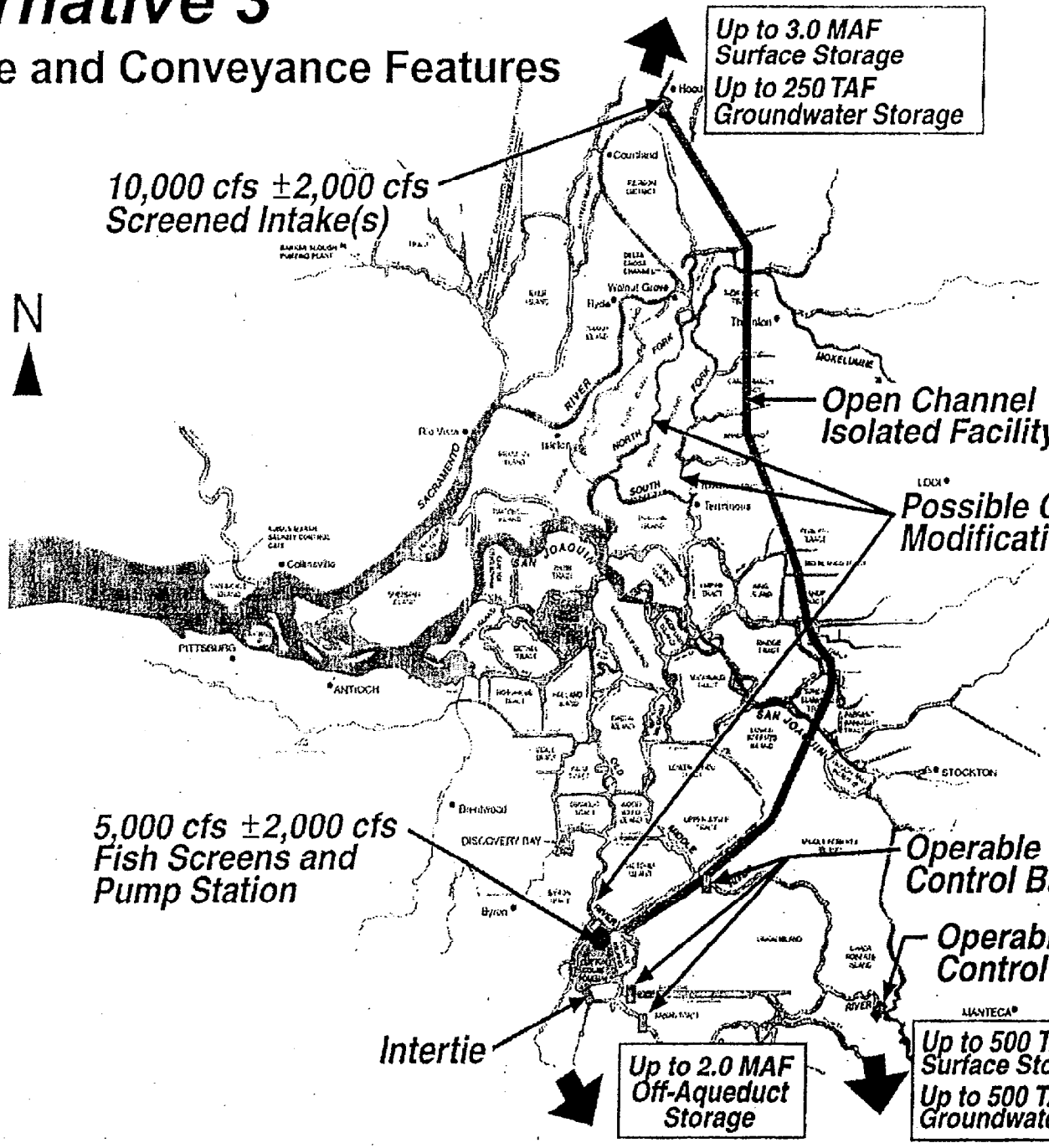


FIGURE 5

There is presently a permit-based export limitation restricting the pumping rate to 6,680 cfs (cubic feet per second) of SWP and 4,600 cfs of CVP; the various CALFED alternatives will increase the permitted pumping rate of SWP to 10,300 cfs (14,900 CFS for combined SWP and CVP), with new storage reservoirs of up to 6 MAF.

From a drinking water perspective, the Sacramento River is a high quality source with low to moderate levels of various inorganic and organic constituents. The San Joaquin River exhibits lower water quality largely due to agricultural runoff within its watershed (its relatively high Br^- concentrations are largely attributed to "recycling" of high-Br^- water from the Delta). There are numerous "islands" within the Delta that are used for agricultural purposes; agricultural drainage from these peat-soil islands further degrades Delta water. The primary impact of agricultural drainage is an increase in organic matter as measured by TOC (total organic carbon), with greater impacts observed during winter when leaching activities are more intensive. The Sacramento River contains moderate TOC ($\approx$ 2 mg/L), relatively low TDS (total dissolved salts, $\approx$ 100 mg/L), and little Br^- ($\approx$ 20 ug/L); the primary impact of seawater interchange is an increase in TDS (seawater contains 35,000 mg/L of TDS) and, in particular, Br^- (seawater contains 65 mg/L of Br^-). The impact of seawater on Delta water quality has been corroborated by tracking the extent of tidal exchange through the ratio of Br^-/Cl^- in seawater. Seawater contains little TOC ($\approx$ 0.5 mg/L).

The location of the major drinking water export facility (Figure 1) is near Clifton Court, which feeds into the H.O. Banks Delta Pumping Plant. Other major export facilities are Rock Slough (the origin of the Contra Costa Canal intake), Barker Slough/North Bay Pumping Plant (the origin of the North Bay Aqueduct), and California Aqueduct/South Bay Pumping Plant (the origin of the South Bay Aqueduct). Thus, these locations represent points of primary concern for drinking water quality.

1.6 Present Drinking Water Treatment Practice for Bay-Delta Water

There are presently over 40 water treatment plants that use Delta water exported through the SWP; a number of other plants use North Bay Aqueduct water, several plants use South Bay Aqueduct water, and several plants use Contra Costa Water District Aqueduct water. While conventional water treatment is widely practiced, there are some direct filtration facilities. Some

of the conventional facilities are being modified or have been modified to implement enhanced coagulation for improved TOC removal; others are being modified to incorporate ozonation.

The Alameda County Water District (ACWD) operates two conventional plants: the first employs pre-ozonation, biofiltration, and free chlorine addition followed by ammonia addition (chloramination); because BrO_3^- levels are highly variable with instantaneous levels as high as 30 ug/L, acid-addition capabilities are presently being installed to permit low-pH ozonation. The second ACWD plant has the same chloramination practice but no ozonation; TTHM and HAA_5 levels range from about 60 to 100 ug/L and 30 to 60 ug/L, respectively. The Santa Clara Valley Water District operates three conventional plants, and is presently designing for intermediate (settled-water) ozonation. The Metropolitan Water District (MWD) operates 5 conventional or direct filtration plants which use SWP or combinations of SWP and Colorado River Water; MWD practices chloramination in the mode of free chlorine contact followed by ammonia addition (typical TTHM levels are 40 to 50 ug/L), and is designing for pre-ozonation and biologically active filters (biofiltration). MWD has done extensive demonstration-scale testing of low-pH ozonation; while BrO_3^- levels can be reduced significantly, acid costs are high and TDS increases (because of acid and subsequent base addition) are significant. The Contra Costa Water District (CCWD) operates two plants: the first is a conventional plant with intermediate ozonation that typically forms <5 to 10 ug/L of BrO_3^-, while the second is an unusual plant that includes GAC with both pre- and post-ozonation. CCWD has built an external storage reservoir to dampen variations in Delta-water Br^-. The Los Angeles Department of Water and Power (LADWP) operates a direct filtration facility with pre-ozonation that occasionally treats a mixture of SWP with Los Angeles Aqueduct water.

In summary, SWP treatment practice largely consists of conventional treatment and includes fairly widespread ozonation and chloramination, but there is little advanced treatment practice involving GAC and membranes. One CCWD facility uses GAC and some pilot testing of membranes has taken place at CCWD, MWD, and ACWD.

1.7 Objectives of Report

The objectives of this report are summarized below:

- Define the sources and occurrence of Br^- (present and projected) in the Delta, and articulate source management options;

- Summarize present drinking water regulations, and project future trends;
- Describe the health effects of Br^- in disinfected drinking water, and identify ongoing/future studies;
- Identify and compare drinking water treatment options for controlling brominated DBPs;
- Contrast treatment versus source management approaches; and
- Make recommendations on short-term and long-term treatment practice and source management, and identify information/research needs.

2.0 Sources and Occurrence of Bromide, and Source Management Options

2.1 Occurrence of Bromide in the Delta

Concentrations of bromide in Delta waters are summarized in Figure 6 (California Department of Water Resources, 1998a); this figure lists bromide concentrations in micrograms per liter (ug/L) for mean measurements and also mean plus or minus one standard deviation at the following monitoring locations: (i) Sacramento River at Greenes Landing; (ii) North Bay Pumping Plant (SWP); (iii) Sacramento River at Mallard Island; (iv) Rock Slough at Old River; (v) H.O. Banks Pumping Plant (SWP); (vi) Delta Mendota Canal at Lindemann Road (CVP); and (vii) San Joaquin River near Vernalis.

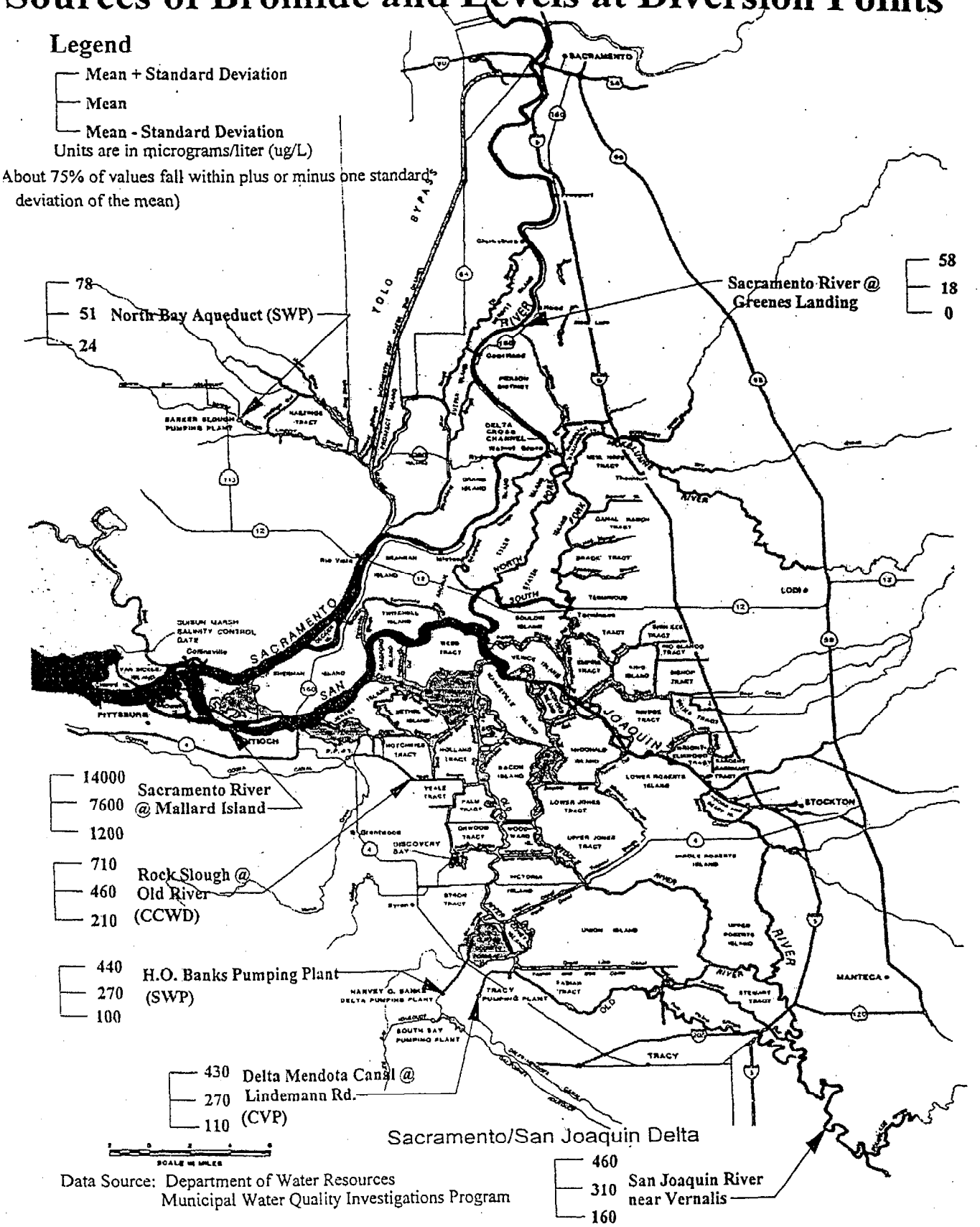
Figure 7 (California Department of Water Resources, 1998a) shows bromide concentrations in Delta channels from October 1994 through September 1997 and Figure 8 (California Department of Water Resources, 1998b) shows bromide concentrations in Delta agricultural drains for the same time period.

2.2 Sources of Bromide in the Delta

The sources of bromide in Delta waters include: (i) sea water intrusion, (ii) recycling of agricultural drain waters from the Delta, (iii) methyl bromide used for soil, commodity and structural fumigation, (iv) discharges from olive processing facilities, (v) discharges from municipal wastewater treatment plants, and (vi) disinfectants used in spas. Apparently, sources of bromide from olive processing facilities, municipal wastewater treatment plants, and disinfectants used in spas contribute minimal amounts of bromide to Delta waters. This statement is based on the fact that Sacramento River water above the Delta typically contains

FIGURE 6

Sources of Bromide and Levels at Diversion Points



Data Source: Department of Water Resources
Municipal Water Quality Investigations Program

FIGURE 7

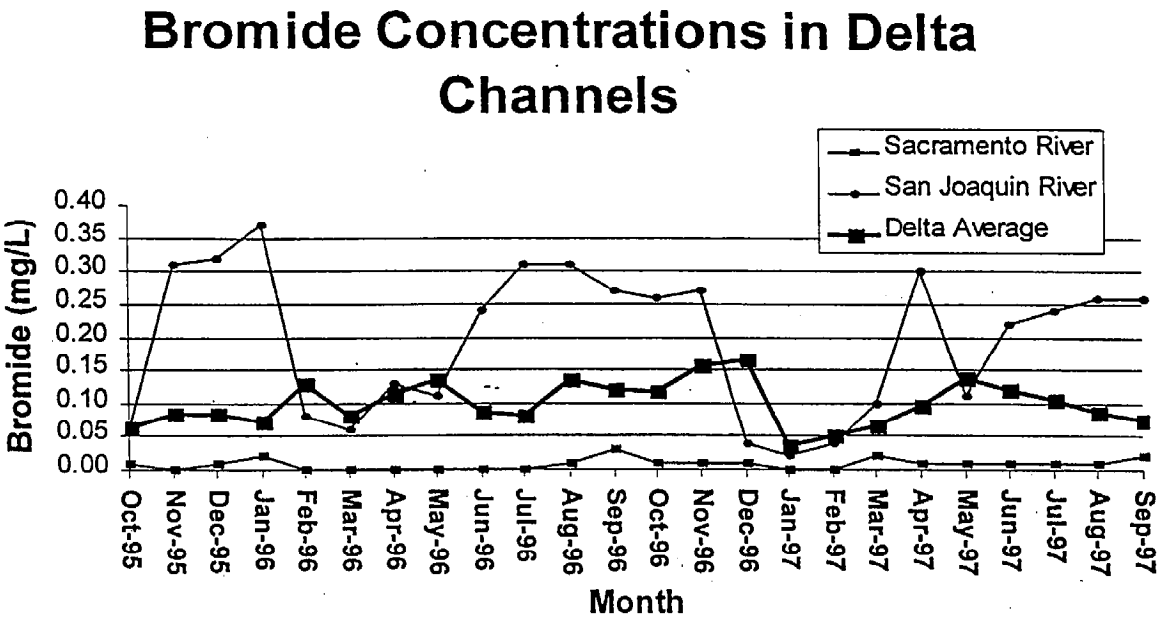
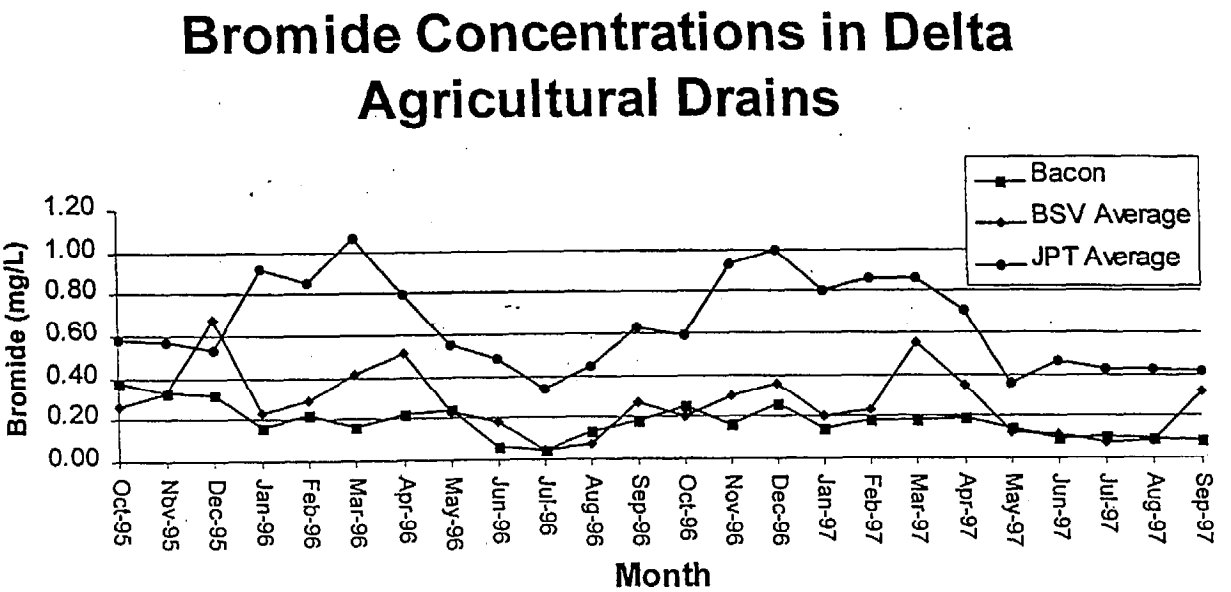

Bromide Concentrations in Delta Channels
Sacramento River
San Joaquin River
Delta Average
Bromide (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Oct-95
Nov-95
Dec-95
Jan-96
Feb-96
Mar-96
Apr-96
May-96
Jun-96
Jul-96
Aug-96
Sep-96
Oct-96
Nov-96
Dec-96
Jan-97
Feb-97
Mar-97
Apr-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Month

FIGURE 8


Bromide Concentrations in Delta Agricultural Drains
Bacon
BSV Average
JPT Average
Bromide (mg/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Oct-95
Nov-95
Dec-95
Jan-96
Feb-96
Mar-96
Apr-96
May-96
Jun-96
Jul-96
Aug-96
Sep-96
Oct-96
Nov-96
Dec-96
Jan-97
Feb-97
Mar-97
Apr-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Month